GEO-CAPE

Geostationary Coastal Ocean and Air Pollution Events

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Program scientists, with Laura Iraci (ARC), study coordinator

February 11, 2009

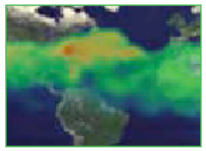
Overview of the mission from the Decadal Survey

Geosynchronous Earth orbit with 3 instruments:

- UV-visible-near IR wide area spectrometer covering 45°S to 50°N hourly (O_3, NO_2, CH_2O, SO_2, Aerosols)
- Steerable, high spatial resolution, event-imaging spectrometer
- IR correlation radiometer for CO mapping

GEOSTATIONARY COASTAL AND AIR POLLUTION EVENTS (GEO-CAPE)

Launch: 2013-2016 Mission Size: Medium



Identification of human versus natural sources of aerosols and ozone precursors

Dynamics of coastal ecosystems, river plumes, and tidal fronts

Observation of air pollution transport in North, Central, and South America

Prediction of track of oil spills, fires, and releases from natural disasters

Detection and tracking of waterborne hazardous materials

Coastal health

Forecasts of air quality

GEO-CAPE NASA Decadal Survey Mission

Science

This mission provides surface reflectance at high spectral, spatial and temporal resolutions from a geostationary orbit

These data will have the spatial & temporal resolution necessary for studying regional scale air quality issues and their impact on global atmospheric composition processes

The data will also be used to address key water quality, ocean chemistry, ecological science questions in the coastal ocean and its response to climate or environmental variability and change

Finally, there is synergy arising from knowledge of the impact of Aeolian inputs to coastal waters and improved atmospheric corrections for all surface retrievals

Architecture/structure:

Three instruments on 1 spacecraft in geostationary orbit: (1) UV-Vis-NIR spectrometer, (2) Event-imaging spectrometer, (3) TIR correlation spectrometer

UV-Vis-NIR Science Measurement:
- N & S America from 45°S to 50°N
- 7 km nadir spatial resolution, hourly repeat
- land and shallow water

-**Event-Imaging Science Measurement:**
- Spectral range, near IR to UV
- 250 m spatial resolution, 300 km FOV
- steerable over land and shallow water

Thermal and near IR Correlation Science Measurement:
-CO observations

FY09 Objectives and Deliverables

- GEO-CAPE workshop report with science traceability matrix

- Refine Level 1 requirements (baseline and minimal)

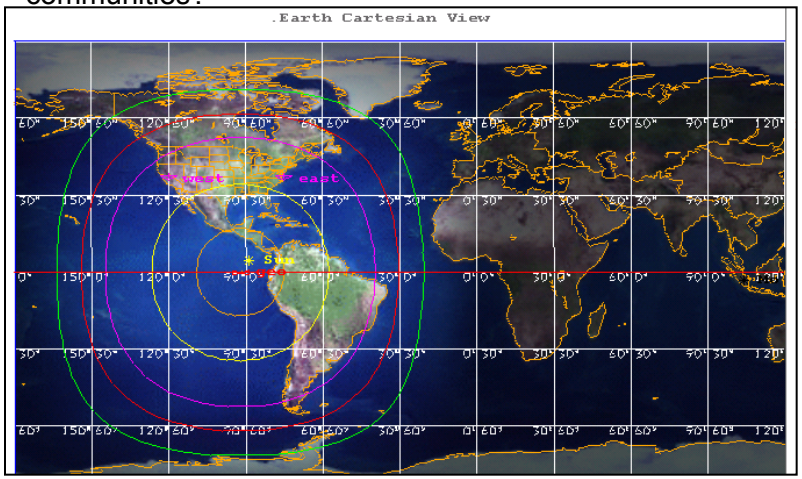
- Mission implementation schedule and other required products for transition to Phase A

- Fall 2009 2nd GEO-CAPE workshop

-Outline steps needed for transition to Phase A, June 2010 time frame.

Mission Implementation Challenges:

- How to balance the science questions of the two communities?



GEO-CAPE Mission Study Overview (1)

- Issues Driving Study Development Team
  - *Science requirements*
    - Nominal baseline requirements from the NRC Decadal Survey
    - These science requirements have been yet to be refined
    - The GEO-CAPE Science Workshop community (~150 participants from AQ and OC communities) began consideration of the requirements
  - *Technology Readiness*
    - Still need to define measurement and instrument requirements, but many people at the centers have good ideas as to the probable solutions, or at least the range of options.
  - *Partnership Interest*
    - Agencies like EPA and NOAA will be very interested users.
    - International Partnerships
      - Only the southern portions of Canada would be covered by the observations
      - ESA and Korea are planning Geo missions as well. Having them operational at
      - the same time has many scientific advantages.
      - Participation on each other's science teams would be useful.

GEO-CAPE Mission Study Overview (2)

Study Implementation Approach

- *Community Buy-in*
  - The 2008 Science Working Group represents a large swath of research and applied science investigators interested in GEO-CAPE. These study group members have been communicating with their broader communities.
  - The 2008 GEO-CAPE Science Workshop included three days of science overviews and breakout sessions dealing with GEO-CAPE science with strong community & governmental involvement.
  - Workshop report was released for community response and final version is imminent.
- *Primary Science Issues*
  - Vertical resolution of trace gases and aerosols within the troposphere
  - Temporal air quality and water quality / ocean ecology and chemical process resolution from a geostationary orbit
    - daily evolution of air quality
    - sub-diurnal ocean processes
    - reduced impact of clouds for high-resolution imager
  - Combined requirement for fine spatial, and frequent temporal resolution and large area coverage presents major technological challenges.

GEO-CAPE Mission Study Overview (3)

Consensus of the Science Study Groups

- *UV-VIS-NIR Spectrometer Science Measurement*
  - 0.5 nm bands from 340 – 1240 nm, SNR > 1000:1
  - 7 km spatial resolution, hourly revisit
  - North & South America land and shallow water
  - Some type of Near IR observation is required for CO
  - The potential of combining thermal and mid IR with UV to get better leverage on boundary level O_3 had a lot of interest, but the concept has yet to be proven.

- *Event-Imaging Science Measurement*
  - 250-500 m spatial resolution, hourly revisit
  - North & South America land and shallow water

- *Mission*
  - Geostationary, high temporal frequency
  - Choice of longitude is important

GEO-CAPE FY08 Study Team Results

- What was Delivered?
  - *A set of initial science questions based on inputs from the 2008 workshop has been established.*
  - *Workshop report has been prepared, needs to be finalized and posted*
- What possibilities were identified/eliminated?
  - *Preliminary examination of mission architecture and instrument design is a necessary next step for FY09.*
  - *Instruments identified for air quality and atmospheric chemistry studies: UV/vis (multiple species); near-IR (CO, O_3, CO_2, CH_4) or thermal-IR (CO, O_3) should allow some vertical resolution*
  - *Several potential ideas for imaging instrument; much more measurement requirements definition needed*
  - *Potential use of hosted payloads suggested as possible cost-saving solution*
- How were results documented
  - *Workshop report, Science traceability matrices,, website*

Synergies with International Missions

- **Geostationary Ocean Color Imager (GOCI): Korean GEO mission**

  > To be launched in late 2009. Data will be used to evaluate the utility of ocean color observations from GEO.

- **Sentinel 3: ESA LEO Satellite for Ocean & Land Imaging**
- **Sentinel 4: ESA GEO Satellite for Atmospheric Composition**
- **JAXA GEO Platform for Atmospheric Composition**

  > Fulfills IGACO vision of constellation of geostationary platforms

Synergies with Other Decadal Survey Missions

•ACE: Aerosol-Cloud-Ecosystems

> Global coverage of aerosols and ocean biosphere
> Active sensors provide high vertical resolution

•HyspIRI: High spatial and spectral resolution LEO mission

> Complements GEO-CAPE in optically shallow areas where high spatial resolution is needed

•GACM: Global Atmospheric Composition Mission

> Suite of passive sensors provides global context of atmospheric composition distribution and can be used to separate stratospheric contributions from total column measurements to infer tropospheric information

Consistent with Integrated Global Atmospheric Chemistry Observations (IGACO) Recommendation to Combine Geostationary and Low-Earth Orbit Satellites

GEO-CAPE Study FY09 Objectives/Plans

- What are the primary activities, being done by whom?
  - *Develop mission requirements from additional workshops* *(Community)*
  - *Coordination of studies and other support functions as necessary* *(L. Iraci)*
  - *Generation of synthetic datasets for atmospheric and ocean analyses* *(JPL, LaRC, GSFC, ARC, CfA, Harvard, NCAR)*
    - Develop regional-scale synthetic dataset for OSSE evaluation air quality parameters.
    - Characterize spatial and temporal variability of targeted species (air quality and ocean parameters)
    - Demonstrate importance of resolving sub-diurnal variability in the coastal ocean using coastal ecosystem and biogeochemical models
  - *Spectral studies and algorithm development* *(JPL, GSFC, ARC, U. Alabama)*
    - Determine best method of acquiring information in planetary boundary layer
    - Determine optimal spectral range and resolution for mission requirements (ocean and atm)
  - *Observing strategy* *(longer term priority)*
    - Determine strategy for sampling cloud-free ocean surface at high temporal resolution using operational satellite weather maps
    - Identify advantages/disadvantages of cycling between variable spatial/temporal resolution on capability to address science objectives

GEO-CAPE Study FY09 Objectives/Plans (2)

- What is the expected mission state at the end of FY09?
  - *Still in pre-phase A*

- How will the results be documented?
  - *Formal presentations and documents delivered to NASA HQ*
  - *Paper and presentations at Science and Application venues*
  - *Updates to the GEO-CAPE website*
  - *Final report as a precursor for KDP-A documentation.*

Potential Studies to Perform with Stimulus Money

- Coordinated ship and aircraft campaigns to refine science questions and establish measurement, mission, and instrument requirements for coastal ocean science
- Development of airborne satellite-simulator instruments with the objective of performing a science demonstration for algorithm testing and refinement, uncertainty analysis, and model comparisons
- Study of hosted-payload concept as a more affordable method for getting an instrument payload into geosynchronous orbit

GEO-CAPE Study Issues and Challenges

- What are the drivers to reaching KDP-A?
  - *Developing a clear and focused schedule, measurement and instrument requirements, as well as mission requirements*
  - *Can the AQ/Ocean science observations be attained with the same set of instruments?*
- What are you focusing your energy on?
  - *Complete GEO-CAPE workshop report*
  - *Continue to iterate with science community on mission science traceability matrix*
  - *Produce GEO-CAPE whitepaper*
  - *2009 GEO-CAPE Science Workshop*
- What cross mission activities are you concerned about but can't afford to deal with?
  - *Would like overlap with ACE, and Aura/GACM*
- What issues are too big for your group?
  - *Platform for GEO, mission design, payload.*
- Are there technology readiness issues that are driving mission readiness?
  - *NASA has never attempted observations for these science objectives from GEO*
- What is the preferred approach for Science Development teams?
  - *Telecons/workshops for those being tasked to do the studies.*

Backup slides…

Overview of FY08 activities (cont.)

GEO-CAPE Science Working Group

Janet Campbell	University of New Hampshire	Ocean Color Satellite Data
Jim Crawford	NASA LaRC	Tropospheric Photochemistry
Curt Davis	Oregon State University	Ocean Color Mission Planning
David Edwards	NCAR	Trace Gas Retrieval
Annmarie Eldering	NASA JPL	Trace Gas Retrieval
Jack Fishman	NASA LaRC	Tropospheric Satellite Data
Daniel Jacob	Harvard University	Global Chemical Transport Models
Randy Kawa	NASA GSF	Trace Gas Measurements
Antonio Mannino	NASA GSFC	Coastal Ocean Biogeochemistry
Richard Scheffe	EPA	Monitoring Networks
Omar Torres	Hampton University	Aerosols

Science Questions and Mission Objectives

Overarching Science Question:

What are the effects of gaseous and particulate emissions on atmospheric composition, air quality, and coastal ecosystems, and how will they respond to climate change and increased human populations?

Science Questions	Mission Objectives
What are the emission patterns of the precursor chemicals for tropospheric ozone, aerosols, and air quality pollutants?	Quantify the diurnal emission patterns of ozone and aerosol precursors, and air quality pollutants over North & South America and the adjacent ocean.
What are the diurnal processes that impact the evolution of gaseous and particulate emissions through chemical formation and loss, transport, and deposition, and how are these processes impacted in a changing world?	Measure the evolution of these atmospheric constituents as they are transformed and transported throughout the day over North & South America and surrounding ocean.
What processes affect and control the biology and biogeochemistry of aquatic coastal ocean zones, and how are they modulated by natural and anthropogenic forcings?	Characterize variability in primary productivity, phytoplankton biomass, and carbon pools in the coastal ocean in conjunction with measurements of natural and anthropogenic forcings.
How do climate variability, anthropogenic activity, weather and the episodic releases from fires and volcanoes affect air quality, river discharge, water quality, and the ecology and biogeochemistry of coastal ecosystems and what are the feedbacks?	Characterize changes in the atmospheric chemistry, hydrology, and coastal ocean biogeochemistry in response to climate variability, human activity, weather events and episodic input from fires and volcanoes.

GEO-CAPE Will Provide Revolutionary Advances in Understanding Air Quality

It will have the spatial resolution necessary for studying regional scale air quality issues and their impact on global atmospheric composition processes

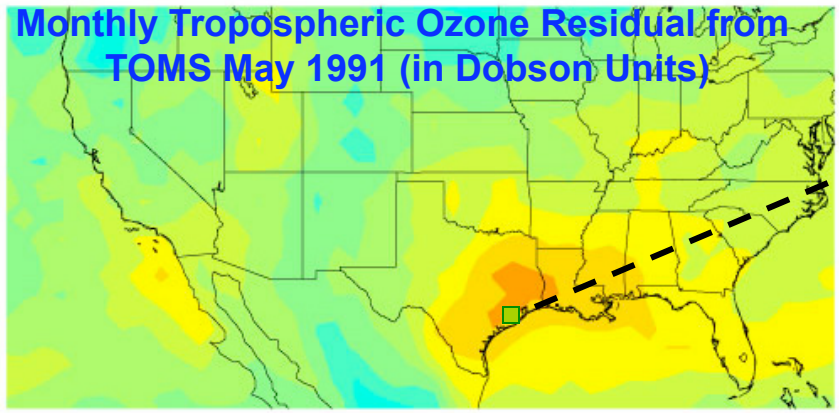
Technology Ready (OMI, MOPITT heritage) for O_3, NO_2, CO, SO_2, CH_2O and aerosols

Spectral Heritage of UV/Vis Measurements

TOMS → **OMI** → **GEO-CAPE**

Monthly Daily Hourly

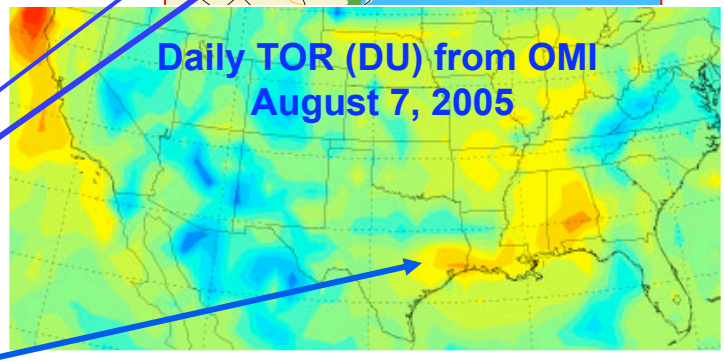
Map of Houston and surrounding area compares pixel sizes from GEO-CAPE, OMI and TOMS



Improved spatial resolution

100 km TOMS

5-10 km GEO-CAPE

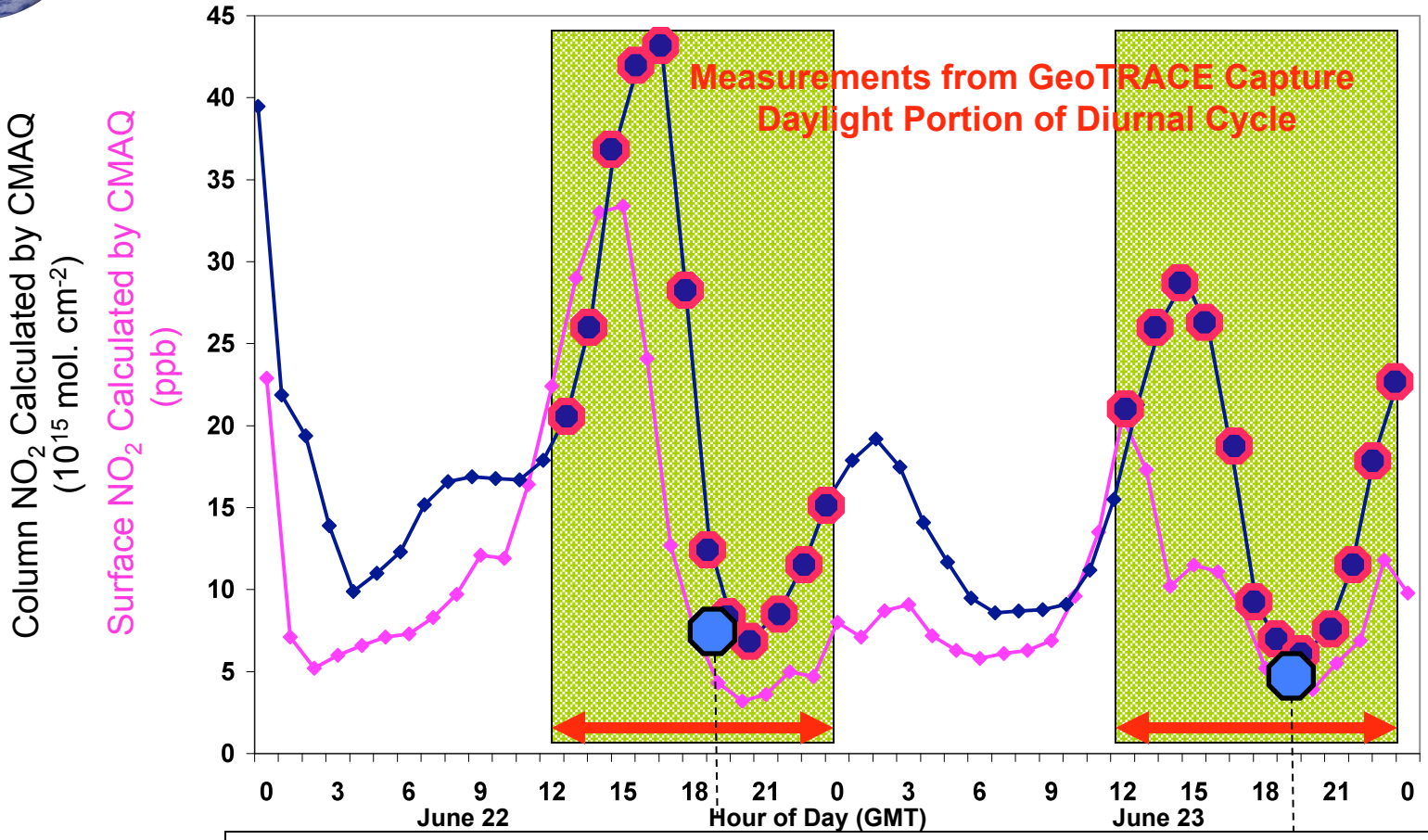


TOMS (Daily) ~100-km res.
(used for monthly climatologies)

OMI (25-50 km res.)
(daily maps)

GEO-CAPE Will Capture Diurnal Cycle of Key Trace Gases and Aerosols

Surface Concentrations and Integrated NO_2 Column Calculated by CMAQ Plotted as a Function of Hour: June 22-23, 2005



Measurements provided only once per day provide relatively little information that can be used to examine how well AQ models perform

GeoTRACE Makes NO_2 Measurements Every 30-60 Minutes Throughout Sunlit Hours

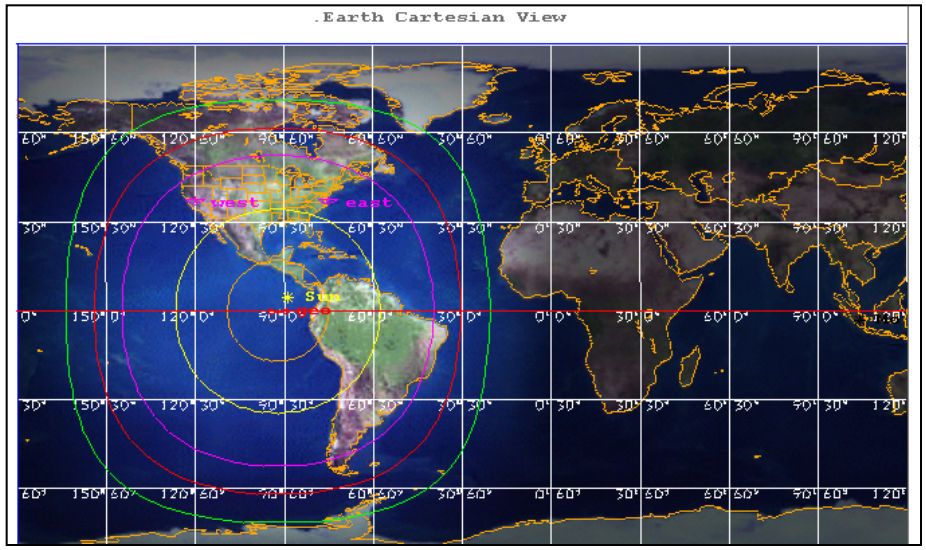
Rationale for Coastal Ocean Observations from GEO

Report of the Panel on
LAND-USE CHANGE, ECOSYSTEM DYNAMICS, AND BIODIVERSITY

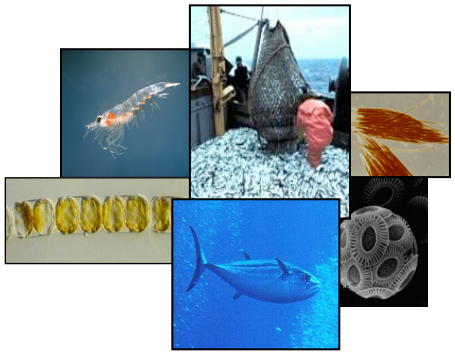
"Coastal ecosystems dynamics mission. The coastal .. oceans are .. important yet poorly observed ... Changes on land and in the open ocean influence the ecosystem services they provide .., such as high-protein food and healthy environments for recreation. Observations several times a day are required to capture the dynamics of coastal ecosystems. ..

…The panel proposes a hyperspectral sensor in geosynchronous orbit over the Western Hemisphere."

Decadal Survey, p. 191



Coastal Ocean Science Questions Addressed by GEO-CAPE



ECOSYSTEMS: How are coastal algal blooms impacted by climate or environmental variability and change? What are the consequences for ..

- living marine resources?
- oxygen minimum zones?
- biodiversity?
- ecosystem health?

HAZARDS: How and how fast do (harmful) algal blooms, oil spills, pollutants and other elements that could be detrimental to ecosystems disperse in the coastal ocean?

CARBON CYCLE:

What is the role of continental margins in the global cycles of carbon and nitrogen?

What are the sources/pathways, forms and fates of carbon and nitrogen to rivers, estuaries, and continental shelves?

What is the contribution of terrigenous organic matter exported to the coastal ocean and to the open ocean?